Space Weather Technical Forecast

Issued on Wednesday 18 December 2024 at 01:12 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: Chance of further Minor Storms (G1) on Day 1, then easing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with a peak C5.9 flare at 17/2146 UTC, which looks to be perhaps from the southeast limb. There are six sunspot regions on the Earth-facing disc. AR3924 (Ehi/Beta-Gamma) remains the most complex sunspot group on the disc, but the region has shown stability. AR3922 (Dai/Beta-Gamma) has shown the most recent development but again, remains stable at present. The Earth experienced a CME thought to be from a filament eruption early on the 15 Dec. Further eruptions were observed off the East limb early on the 17 Dec, unlikely to be Earth-directed, followed by a notable halo CME at 17/1600 UTC. From analysis this looks most likely to be far-sided with limited impact to Earth.

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE and DSCOVR at L1, showed a significant increase during the early hours of the 17 Dec with the arrival of a CME at 17/0437 UTC. Solar winds peaked at 700km/s around 17/0900 UTC but have since slowed to Slightly Elevated levels at 500km/s. Density rose sharply above average to around 47ppcc at 17/0530 UTC with the arrival of the CME but has since dropped to below average. The Interplanetary Magnetic Field (IMF), Bt, was initially weak but rose to 30nT by 17/0632 UTC retuning to Moderate levels from 17/1800 UTC. The north-south component, Bz, oscillated between -21 and +27nT during the turbulent region of the CME between 17/0437-0900 UTC, staying largely positive before becoming moderately negative by the end of 17 Dec. The phi angle fluctuated during the arrival of the CME and since has settled negatively (towards the Sun). This activity resulted in a G2 Moderate storm between 0300-0900 UTC, followed by a G1 Minor 0900-1200 UTC, and is currently at Unsettled activity (Kp3).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels, though a minor enhancement in 10MeV levels was indicated between 17/0000-17/0600 UTC due to the unexpected CME arrival. A further peak in proton flux was observed at 17/1915 UTC believed to be related to the far-sided halo CME. High energy electron flux (greater than 2MeV) observed by GOES16 was background. The associated 24-hour fluence was well below the Active (1e8 integrated flux) threshold. The 18/0000 UTC observation was 1.27e6 integrated pfu.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate Solar activity is forecast with a chance of M-class flares, increasing gradually through the forecast period.

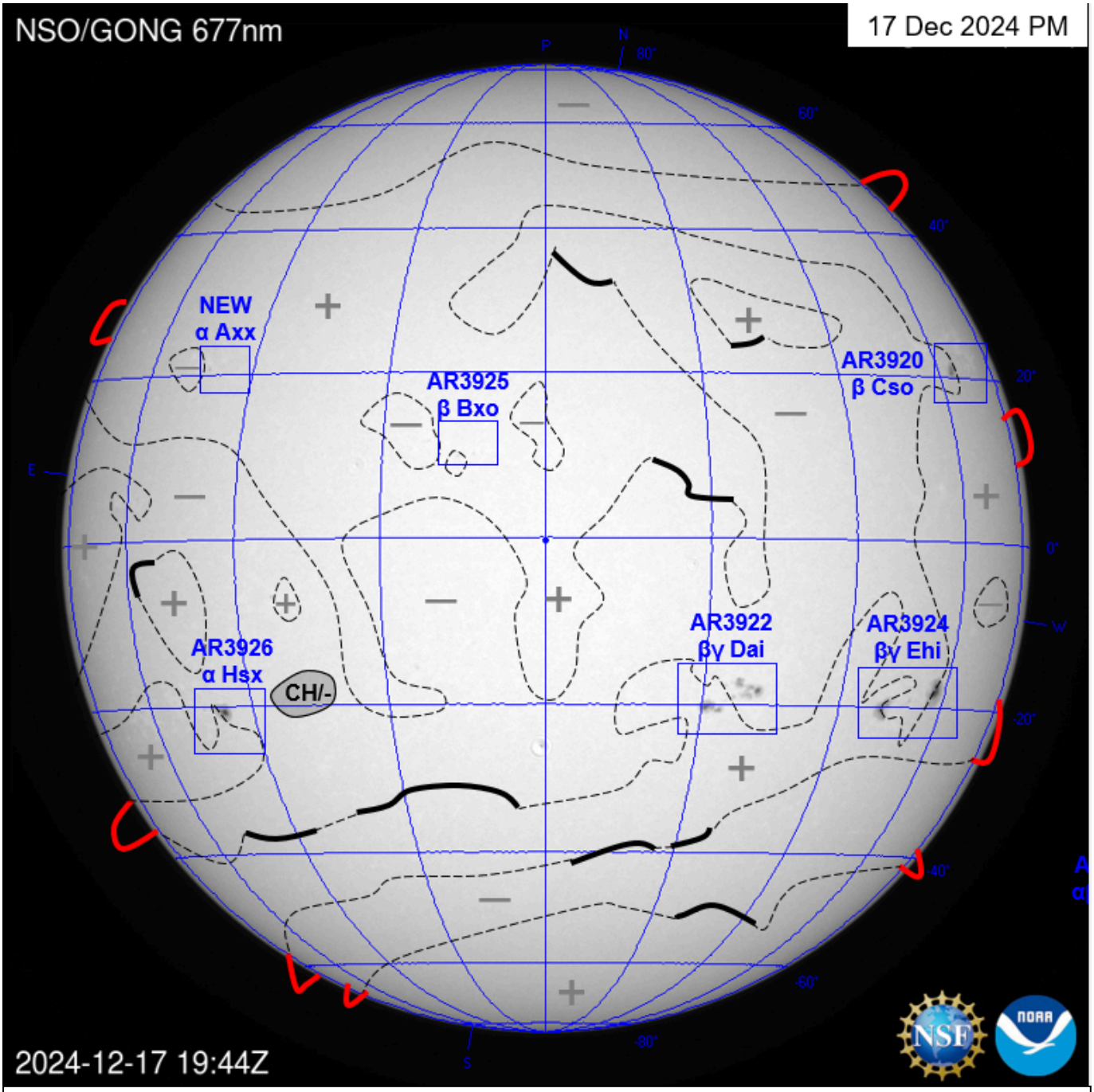
Solar Wind / Geomagnetic Activity: The CME experienced at Earth during the morning of 17 Dec is likely to continue to wane through the early part of Day 1 (18 Dec), with a chance of isolated G1 Minor storms possible until it does. Then a reduction back to Quiet to Unsettled (Kp1-3) conditions. Several other CMEs that left the Sun in the past few days are forecast as near misses, but cannot be completely ruled out as flanking arrivals at Earth, so there is some uncertainty in the forecast currently.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but carries a slight chance of reaching S1/Minor Storm levels or greater, in response to any notable solar flares. High energy electron flux may increase to moderate with diurnal peaks of high. However, the 24-hour fluence is expected to remain below the Active threshold throughout.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 1: Solar Synoptic Map valid 17/1944 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Storms

The unexpected CME which arrived at Earth early on the 17 Dec is thought to be associated with a large and complex filament eruption that occurred early on the 15 Dec. Most of the ejecta from the filament appeared to go south and west out of the solar system and away from Earth, but there was evidence of a very faint and fast shock front emanating from the Sun shortly afterwards, as seen only on STEREO A coronagraph. The currently solar wind remains elevated with speeds around 600km/s, this is expected to ease through Day 1 (18 dec) and allow for geomagnetic activity to return to Quiet to Unsettled (Kp1-3). Any previous estimations of CME arrivals are likely to have been swept up and are no longer forecast to have any impact on Earth.

A halo CME was evident in Lasco imagery around 17/1600 UTC, however this appears to be farsided with minimal impact to Earth currently expected. There have been no further significant CMEs observed in the Earth-Sun line. A few other filaments have also erupted early on the 17 Dec, but are not thought to be Earth-directed.

MOSWOC Enlil shows the arrival of the CME at Earth on 17 Dec and is followed with reasonable confidence, however wind speeds are likely to be elevated in the output. No coronal holes are expected to play in the forecast period, so once the current CME impacts have subsided, it is likely we will see a return to Quiet to Unsettled (Kp1-3) conditions through the course of Day 1 (18 Dec).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	Yes	40	10	5	5
Strong	**G3**	No	5	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

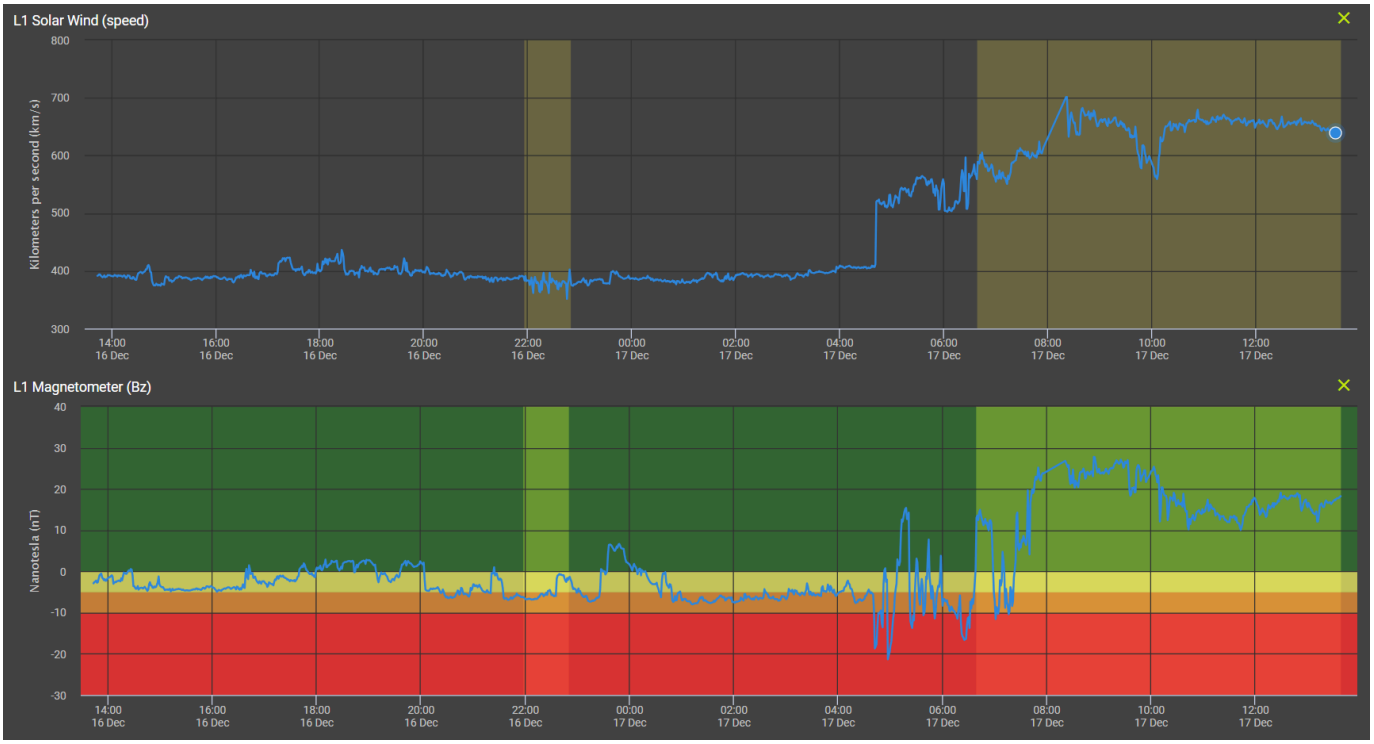
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
2024-12-15 10:43	Partial	Filament	SW	481	18/1900 UTC	A part of this CME has likely arrived already at Earth (timing 17/0437UTC), travelling much faster than initially observed.

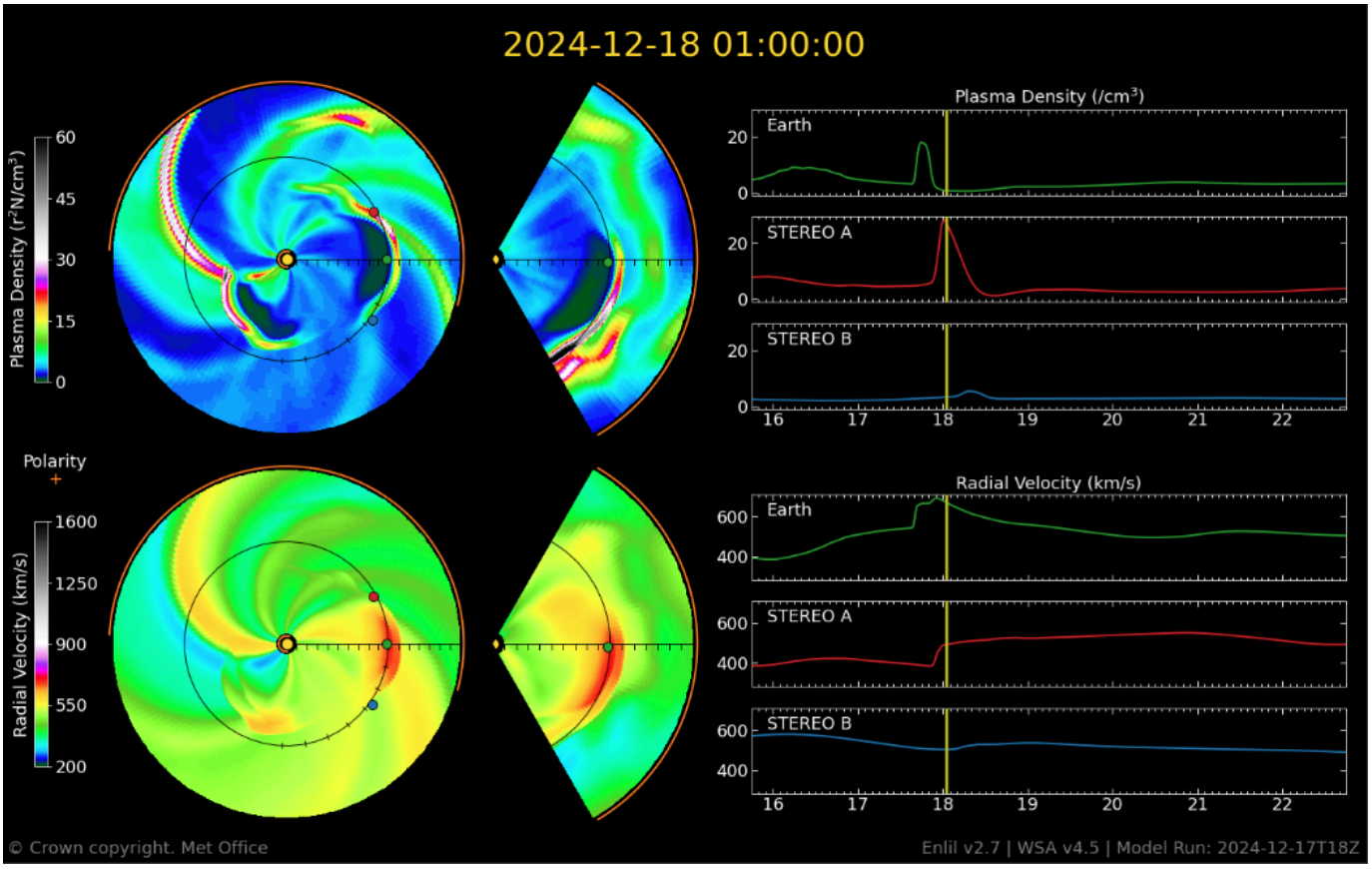
Figure 2: Solar wind speed (top) and Bz component (bottom) from DSCOVR/ACE(highlighted) showing sharp rise in activity from 0437UTC on the 17th as the CME arrived. Strongly positive magnetic cloud during the morning.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 3: MOSWOC Enlil output.



© Crown Copyright 2024. All Rights Reserved.

Radio Blackouts - X-Ray Flares

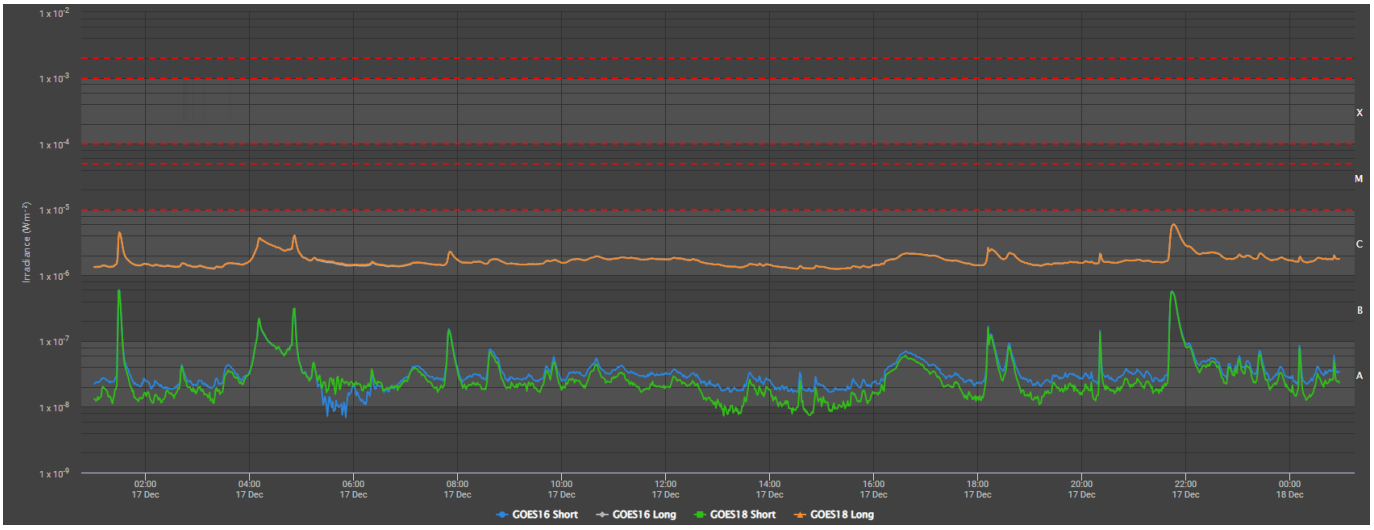
Solar activity has been at Low levels for the last 24 hours with 6 active regions only giving isolated C-class flares. AR3924 in the southwest remains the most complex region and consists of a large, symmetrical leading spot and a smaller, but irregularly shaped trailing spot. It has shown some signs of decay with many of the intermediate spots beginning to fade. AR3922 also in the southwest remains the most developmental group on the disc. It continues to show signs of growth with emergence of spots in all parts of the group. Despite this the region remains largely stable and inactive. The remaining regions on the disc are smaller and more magnetically simple, including a new, unnumbered region in the northeast.

There continues to be the likelihood for further regions to rotate onto the disc from over the east limb between Days 1 and 2 (18-19 Dec) corresponding to Ex-AR3902, Ex-AR3905 and Ex-AR3906. The latter two produced M-class flares when they were last on the facing-disc and recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

Low to Moderate Solar Activity is forecast with a chance of M-class flares increasing to become more likely from Day 2 (18 Dec) onwards.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	40	50	60	60
Very Active	R3-R5 (X Class)	No	5	5	5	5

Figure 4: GOES 16 & 18 X-ray trace.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Solar Radiation Storms (High Energy Protons)

GOES18 proton flux is at background levels. There is a continuing slight chance of reaching S1/Minor Storm levels or greater, in response to any notable solar flares, currently most likely from AR3924. This region will likely rotate over the western horizon on Day 3 (20 Dec), but proton storm probabilities are maintained for at least 24-hours after it leaves the visible disc.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

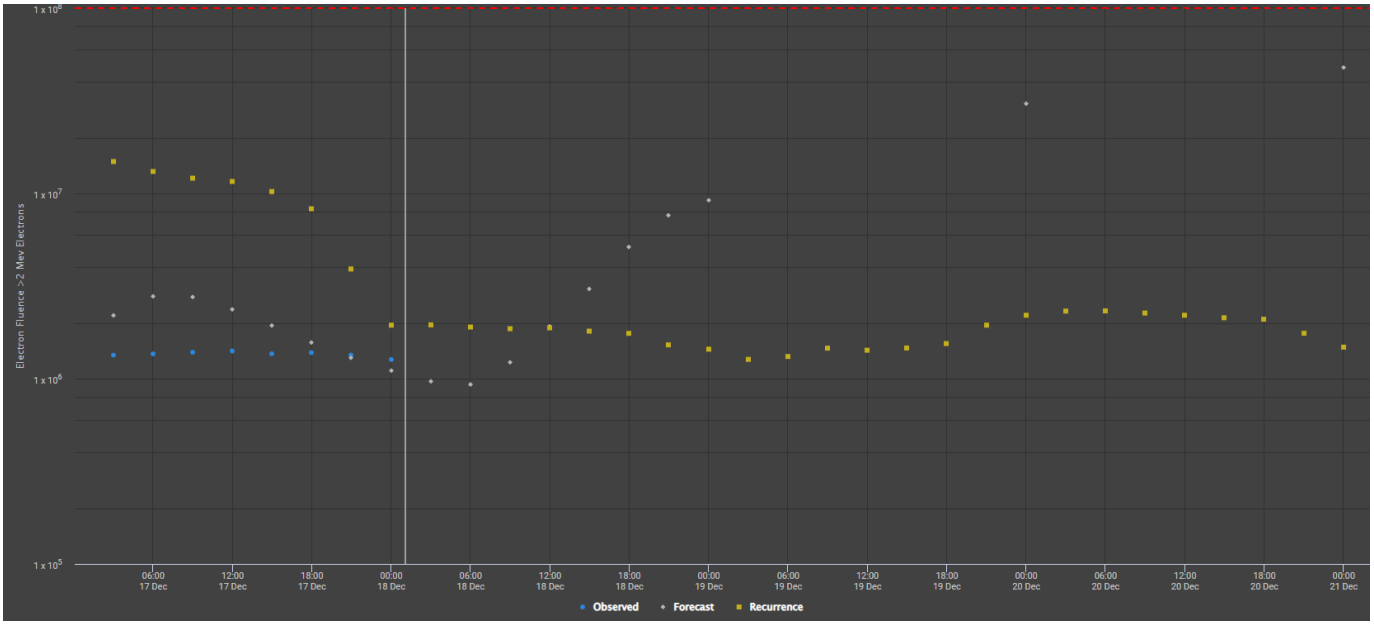
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been at largely background levels following the influence of the recent CME arrival causing the electron belts to become compressed away from GEO. However, as the Van Allen belt relaxes and expands back towards GEO in the coming days the electron flux at GEO may rise to moderate, perhaps peaking a high levels within the diurnal cycle.

There is only a very slight chance that the electron flux will be maintained at high levels for over 24 hours, with the expected outcome for the associated 24-hour fluence to remain below the Active (1e8 integrated flux) threshold throughout the forecast period. MOSWOC REFM output is considered to be providing good guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	5	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REFM output.



© Crown Copyright 2024. All Rights Reserved.